Neutrino Self-Interactions

Nikita Blinov

September 17, 2020

NF03 Kick Off Meeting

Based on LoI with Mauricio Bustamante, Kevin Kelly and Yue Zhang

SNOWMASS21-NF3-003

Self-Interactions in the SM

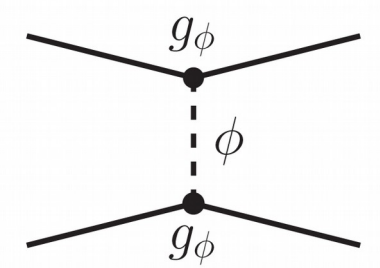
- Neutrino self-interactions are some of the most difficult operators to probe in SM EFT

$$\frac{G_F \rho}{\sqrt{2}} (\bar{\nu}_L \gamma_\mu \nu_L)(\bar{\nu}_L \gamma^\mu \nu_L)$$

Need a cosmic ν with $E_\nu \sim 10^{11}$ GeV to scatter once off CνB over distance H^{-1}

Weiler (1982)

- Lots of room for beyond SM contributions

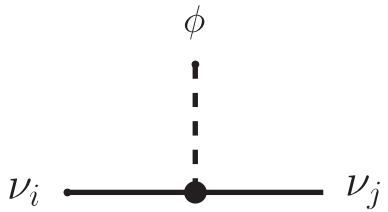


Self Interactions Beyond the SM

A wide range of motivations

Neutrino Mass Generation

Models with a Higgs mechanism in the neutrino sector



See, e.g., Chikashige *et al* '81
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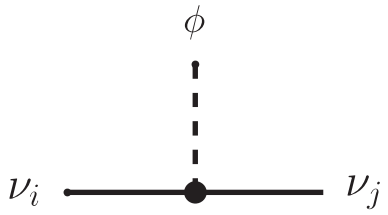

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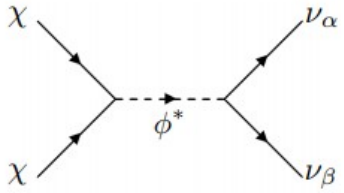
Dark Matter

Predictive models of thermal (WIMP-like) or non-thermal (freeze-in) dark matter



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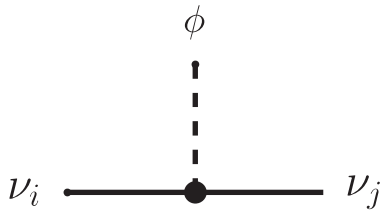

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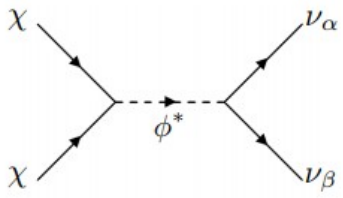

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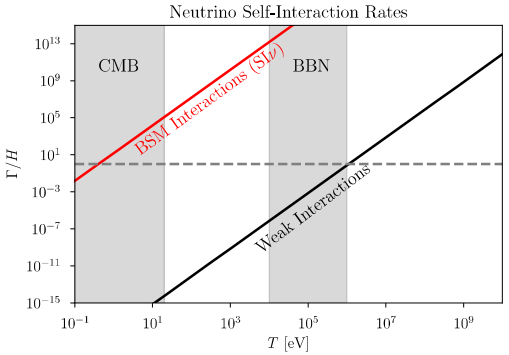
Observational Anomalies

Hubble tension alleviated via neutrino self-interactions



Kreisch, Cyr-Racine & Doré (2019)

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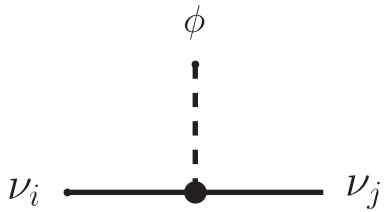

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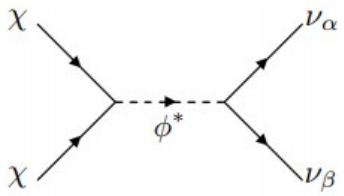

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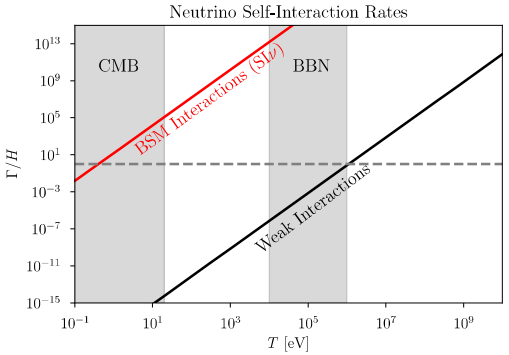

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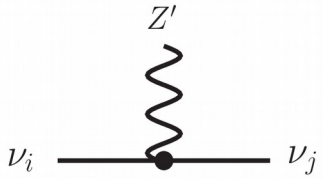
Theoretical:

U(1) anomaly-free extensions of SM include new neutrino couplings: B-L, L_i-L_j...



Observable Consequences

Accelerators & Lab:

- Rare decays of mesons and taus
- Oscillation and neutrino scattering exp.
- $0\nu\beta\beta$ searches
- ...

Astrophysics

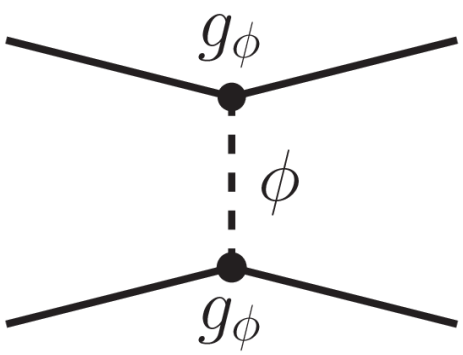
- Cosmic neutrino propagation
- Supernova physics
- Stellar evolution
- ...

Cosmology:

- Microwave background
- Light element abundances
- DM clustering
- ...

These span a huge range of energies, an EFT treatment is not possible

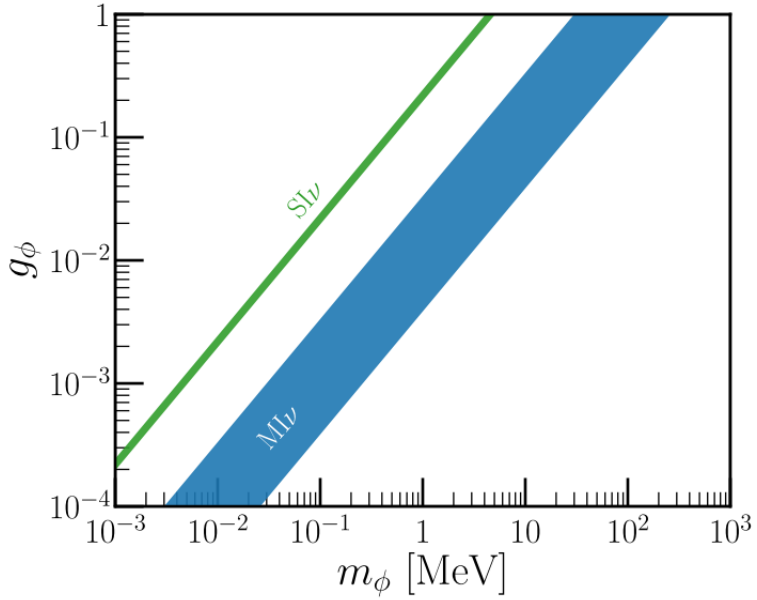
Complementarity Example



Hubble tension can be alleviated by neutrino self-interactions during the CMB era

$$G_{\rm eff}({\rm SI}\nu) \sim 10^9 G_F$$

Kreisch, Cyr-Racine & Doré (2019)



NB, Kelly, Krnjaic, McDermott (2019)

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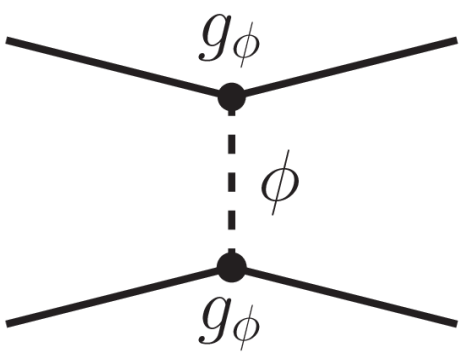

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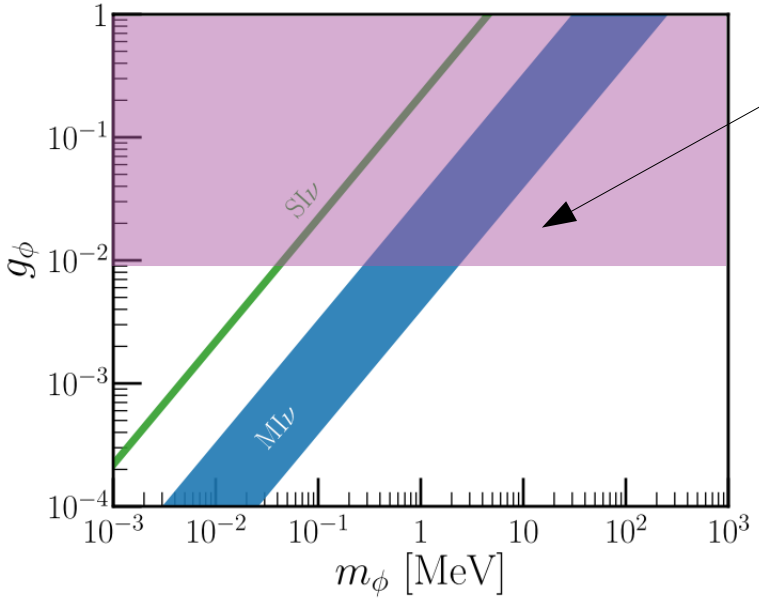

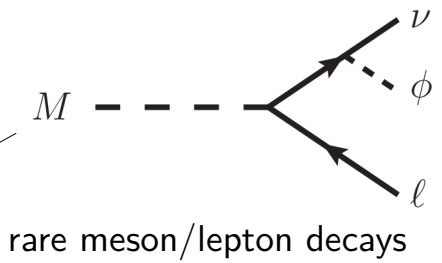

rare meson/lepton decays

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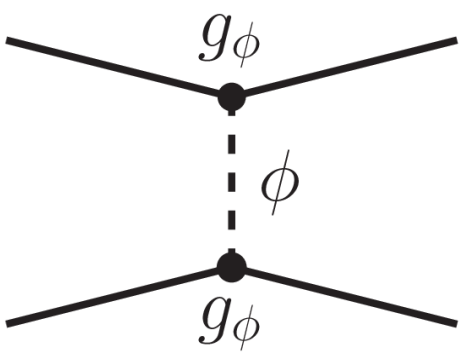

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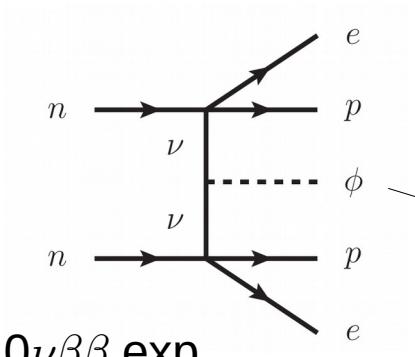
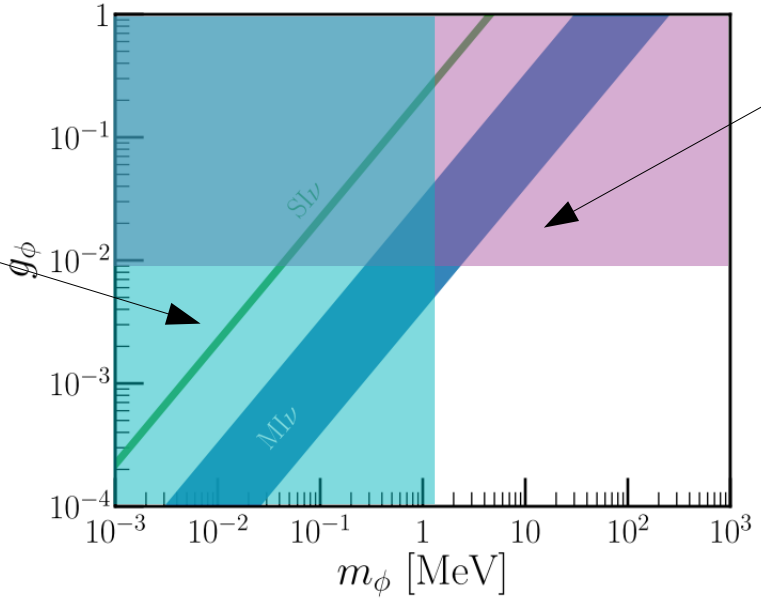
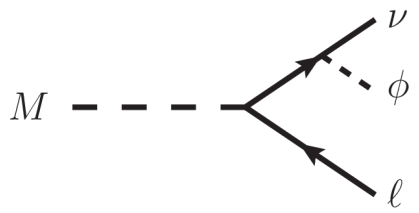


$0\nu\beta\beta$ exp. and light element abundances





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Goals for this Whitepaper

- Define a set of benchmark models
- Comprehensively review phenomena within these common theoretical frameworks
- Identify gaps in sensitivity and opportunities

Thank you!